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Canada, Mines and Technical Surveys, Department of. Explosives Division

The Handling of EXPLOSIVES

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DEPARTMENT of MINES and TECHNICAL SURVEYS

EXPLOSIVES DIVISION, OTTAWA, 1956

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INTRODUCTION

The fact that both labour and time can often be saved through the use of explosives is common knowledge and as a result blasting operations are frequently undertaken by inexperienced persons. In land clearing, for example, it is customary for farmers themselves to undertake the work. Experience in the use of explosives, however, cannot be gained safely through trial and error; some knowledge of the basic principles of blasting is necessary if serious hazards are to be avoided.

The purpose of this booklet is to emphasize the safety principles that should be observed in the handling of explosives and in blasting. The matter of selection of a particular explosive and details of specific application are not dealt with; guidance on such points should be sought from explosives manufacturers. Some manufacturers have published manuals in which safe and efficient blasting practice is covered in great detail, and their use is highly recommended. Manufacturers are most generous with assistance and sound advice to users of explosives.

The Explosives Act, which is the prime concern of this Division, does not cover the actual use of explosives, but does apply up to the time when the blaster takes his explosive charge, his detonator and his safety fuse from storage. However, the keynote of this Act is SAFETY, and the following text has been prepared to promote and foster the highest safety principles and thus help to eliminate human suffering and material loss.

TRANSPORTING EXPLOSIVES

In the mind of the average person the term "explosive" immediately raises thoughts of destruction and fear. Too often such thoughts are tempered by the indifferent attitude of a "know-it-all" neighbour or acquaintance who has had "experience" in such matters. Remember that explosives play no favourites, they demand the highest respect from expert and novice alike.

The person who purchases a small quantity of explosives for his own use will, in all probability, have to take delivery from a railway agent or magazine keeper. His first consideration should be the manner of transporting by road to his own prepared place of storage, bearing in mind the nature of the road to be traversed. Regulations covering such transportation are in effect, and attention is here drawn to a few salient points only:

(*a*) The vehicle must be mechanically sound.

(*b*) Explosives should be secured in the vehicle in such a way that jolting or sudden or unexpected stops cannot cause shifting or other movement.

(*c*) Detonators should never be conveyed with dynamite or stumping powder. Explosion of the dynamite through the accidental firing of the more sensitive detonators is an ever present danger.

(*d*) No other goods of a dangerous or easily combustible nature, such as greasy rags, oil, matches or gasoline, should be in the same vehicle.

(*e*) It is an offence to smoke within or on a vehicle carrying explosives.

(*f*) The speed of a vehicle transporting explosives shall conform to all local traffic laws, ordinances and by-laws, shall be consistent with road and weather conditions, but shall in no case exceed 40 miles an hour.

(*g*) The driver should make every effort to avoid stopping near occupied buildings or groups of people, and he should keep his load under his own observation at all times until he has deposited the explosives in the magazine.

(*h*) If the quantity transported is more than 50 pounds, the vehicle must bear "EXPLOSIVES" signs easily visible from front, rear and sides. The word "EXPLOSIVES" must be at least 6 inches high and painted with luminous paint on a contrasting background. The signs must be covered or removed when no explosives are carried.

KEEPING EXPLOSIVES

The conditions under which explosives should be kept vary according to the quantity involved. In this text consideration is given to the handling of quantities of probably not more than ten cases (500 pounds) of dynamite and 2,000 detonators.

Ten pounds or less of blasting explosives and 200 detonators (blasting caps) may be kept by the owner in separate, locked receptacles. Such receptacles should be at least 10 feet apart, and their locations chosen carefully with regard to ease of access, danger of theft, risk from fire and possible tampering by

children. Each should be made of wood, copper or other suitable material, fitted with a substantial lid or door, and marked conspicuously with the word "EXPLOSIVES", on a contrasting background.

Usually, however, it will be a question of storing several cases of dynamite or stumping powder, and for such storage the following advice is given:

Statistics prove that a large number of explosives accidents, particularly to children, are the direct result of stocks which have been abandoned and forgotten, only to be discovered later and tampered with by the innocent victims. When ordering supplies of explosives and detonators a good measure of foresight should be used as to quantities needed. Not only is there the possibility of accidents by tampering, but explosives are very liable to deteriorate, particularly under varying temperature and humidity conditions. Thus the sensitive nitroglycerine of the explosives may leak, causing a dangerous contamination on the one hand and the possibility of cartridge impotency on the other.

The Explosives Regulations stipulate that a quantity of blasting explosives not exceeding 150 pounds and a quantity of detonators not exceeding 2,000 may be kept for use, but not for sale, in separate, detached stores without a licence. However, and particularly with regard to the storage of dynamite or stumping powder, a detached store must be constructed of some fire-resistant material, or of wood covered or treated with fire-resistant material; or it should consist of a substantially constructed bin, of not less than 2-inch lumber, and covered or treated with fire-resistant material. The storage must be detached from any dwelling house, and at a safe distance from any highway, street or public place.

It must be fitted with a good lock, marked with the sign "EXPLOSIVES" on a contrasting background, and kept for the storage of explosives *only*.

Except under certain conditions, the storage of more than 150 pounds (3 cases) of explosives is illegal, unless such storage is licensed. If it is desired to store more than 150 pounds the Chief Inspector of Explosives, Explosives Division, Ottawa, or an Inspector of Explosives should be consulted or written to. It is unwise to build a magazine first, and later make application for a licence on the assumption that the licence is but a legal formality. Every magazine must have the approval of the Chief Inspector of Explosives before a licence is issued, and such approval can only be given if the magazine comes up to certain standards of construction, physical location (having regard to drainage, etc.) and distance from highways, railways, houses, etc.

The proper storage of a few sticks of high explosives may be as important as that of a few cases, inasmuch as gross negligence could cause the loss of life in either case.

It must be remembered that explosion—*without a detonator*—may be brought about by friction, heat, or shock. Each one of these factors is of vital importance in storage.

Friction: The chief explosive ingredient of most high explosives is nitroglycerine, and the sensitiveness of this dangerous chemical is particularly high. Where there is laxity in proper supervision and magazine housekeeping, leakage of pure nitroglycerine from the cartridges may occur. If disregarded, the leaking nitroglycerine is in turn absorbed by the cases, the

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magazine floor and the ground underneath the magazine. If the floor has been permitted to become gritty the situation inside the magazine is now ripe for an explosion through friction, impact or a combination of both. All that is now necessary for an explosion is the slithering or scraping of a hob-nailed or caulked boot across the pregnant surface. This is not theory; it is proven fact. Thus constant vigilance, good housekeeping and impeccable magazine habits are vital.

Heat: It is commonly assumed that high explosives will burn like any ordinary combustible substance. Under most circumstances that is true, but under certain other circumstances any application of heat would be explosively disastrous. The intentional burning of explosives for any reason whatever must be left to the expert or specialist who understands the proper technique, and under no circumstances whatever must any user experiment simply for his own satisfaction, or perhaps to prove to a neighbour, that 'the stuff burns'. More often than not dynamite or stumping powder, if contained in an unopened case, will explode at some phase when the case is ignited. Consequently, in case of fire which may threaten a magazine, the stock should be removed at once to a place of safety.

Many small operators show an utter disregard for weatherproofing and ventilating their magazines. In addition to creating unsafe conditions such a disregard can be most uneconomical. Stumping powder, for instance, becomes quite inert when in contact with water for even a relatively short period. Even the normal blasting explosives which are semi-gelatinous lose their potency in time when directly associated with water. Thus it is obvious that for best

results, and to offset the possibility of misfire later on, the magazine should be kept absolutely weatherproof. At the other extreme, weatherproofing does not mean the exclusion of adequate ventilation, because proper ventilation is just as necessary as water is harmful. Air circulation should be assured to help offset temperature extremes, particularly the higher extreme with its consequent and undesirable promotion of nitroglycerine leakage. Vents should be baffled or otherwise protected from rain. To help cope with high summer temperatures aluminum sheeting to cover magazines is coming into wide use; as a further and inexpensive aid, cases may be placed on floor slats, and kept free from contact with the magazine walls.

Shock: Commonsense dictates that high explosives be given the treatment which their unpredictable nature demands. Nitroglycerine is extremely sensitive to shock; therefore the dropping of a case, or even one cartridge, must be regarded as an explosive possibility.

Considering all these possible sources of explosion it must be obvious to the magazine owner or operator that his responsibility is a heavy one. He must be aware that any but approved storage conduct and practice is fraught with grave danger.

USING EXPLOSIVES

An appreciable number of blasting accidents, some of them fatal, can be traced directly to the gross inexperience of the small or intermittent user. The object lesson may be summed up in this simple couplet:

When in doubt about a task
Why should you be scared to ask?

Before touching on the actual use of explosives a little more consideration should be given to the explosives themselves, and to the other accessories which make up the blasting cycle.

Due to cold weather, winter land clearing is not usual in most Canadian provinces, but it sometimes becomes necessary to use explosives for other purposes in winter. Modern Canadian explosives will not freeze at normal cold temperatures, but in extremely low temperatures they may become hard and lose some of their strength. Under no condition should artificial softening be resorted to by an inexperienced amateur. The proper procedure is to maintain the explosives at room temperature until the desired consistency has been obtained.

Explosives which have deteriorated due to contact with water or exposure to high temperature and humidity, should not be used. Such explosives are usually soft and soggy, and sometimes the ingredient salts are crystallized on the outside of the cartridge wrapper. Advice should be sought regarding immediate disposal of such explosives.

Safety fuse is as important as any other link in the blasting chain, and consequently must be carefully stored and handled. Burning speed is designed to be 40 seconds per foot, with an allowable variation of 10 per cent either way (fast or slow). For general practical purposes, however, it is wise to assume that the burning speed is 2 feet per minute. But it should be remembered that the burning speed increases with elevation.

Regulations covering underground and surface blasting stipulate that *'No fuse shorter than 3 feet shall be used in any blasting operation, nor shall any fuse be lighted at a point closer than 3 feet from the capped end'*. There are many private users of explosives whose operations are governed by no Regulations. However, since the stipulated minimum length of fuse has been set to protect organized industry, such private users are well advised to be governed accordingly.

Conditions under which fuse is stored can have an important bearing on blasting operations later. Improperly stored fuse can dry out or become damp. If dried out, it becomes hard and brittle and when bent may rupture so that the train of powder will be broken and cause a misfire; if it becomes damp, the powder-treated core may absorb enough moisture to render the fuse useless, or at least dangerously unreliable. For best results fuse stocks should be kept in a dry place at an even normal temperature. In use it is well to handle it carefully. Avoid bruising and sharp or unnecessary bending.

Detonators (blasting caps) do the same thing for explosives that spark plugs do for automobiles, but they are infinitely more dangerous and sensitive. Like explosives, they may be accidentally fired by

friction, heat or shock, but much more easily than their explosive partner. To do its job, a detonator must be a highly sensitive mechanism and until it is safely placed with the primer in the shothole, it must be treated with the utmost delicacy. So sensitive is this little innocent-looking aluminum shell, that it will explode from any of the following causes:

(*a*) Slight compression of the explosive end.

(*b*) Picking the explosive ingredients.

(*c*) Heat—(flame or sparks).

(*d*) Induced explosion through close proximity to another detonation.

Blasting: The field of blasting is so wide and varied that only the simplest standard procedure can be mentioned here as a basic guide to the inexperienced. For safe blasting, using standard safety fuse, here are the proper steps in sequence:

1. Study the situation on hand, and be assured that it calls for blasting.

2. Don't guess the amount of the charge. Seek advice if necessary.

3. Clean the shothole thoroughly.

4. Bring the fuse roll and the charge of explosives to the site of the proposed shot, then make a separate trip for the detonator.

5. Cut off a length of fuse about a foot longer than the length of the hole, or $3\frac{1}{2}$ feet, whichever is longer.

6. Cut 1 inch from either end of the fuse length, squarely and with a sharp knife.

7. Insert this end into the open end of the detonator and gently push it home, avoiding any twisting or undue pressure.

8. With a pair of crimping pliers, gently, but firmly, crimp the detonator on the fuse about an eighth of an inch (not more) from the open end.

9. Open a cartridge wrapping at one end and, using a pencil-shaped piece of hardwood, pointed at one end, make a hole in the cartridge about 2 inches deep.

10. Into this hole push the detonator with its attendant fuse, wrap the opened cartridge paper around the fuse at the insertion and tie snugly with string. Your primer is now prepared.

11. With a wooden rod ascertain if the shothole is free from obstruction and ready for the charge.

12. Using a flat-ended wooden tamping rod (never metal) press the first cartridge of the charge to the bottom of the shothole and follow by gently pressing the primer next. Press the balance of the charge home, one cartridge at a time, being cautious not to damage the fuse.

13. Using fine sand, clay or earth (but never rough gritty material) loosely tamp about two handfuls of stemming material against the charge. Continue tamping a little firmer until the shothole is filled to a point about 12 inches from the collar.

14. Cut about an inch from the protruding end of the fuse, split the exposed end with a sharp knife and turn back each side to expose the powder train.

The shot is now ready for firing, but before doing so the shotfirer must be assured that everyone is clear of the danger area and that every approach is guarded or otherwise satisfactorily stopped. Finally he should shout "FIRE" and ignite the fuse.

If these instructions are carried out faithfully and in sequence there is little chance that the charge will not explode. However, should it fail to explode, no one should approach the hole until a period of at least half an hour has elapsed. A close examination of the protruding fuse may show that the 'spit' did not catch. If such is the case, 1 inch may be cut from the fuse, the end slit and the sides turned back, and the exposed end relit. This procedure can be safely undertaken only once.

Should the hole prove to be a true misfire, *no attempt must be made to pull out the fuse* or otherwise interfere with the tamping or the charge. Normally the safest procedure in such cases is to make up a fresh primer, insert it in the 12-inch empty length of shothole and reblast, taking care that the new fuse is at least 3 feet long. There is every likelihood that the second primer will explode the parent charge, but a careful search of the debris must be made for possible unexploded cartridges and particularly the original primer.

Stump Blasting may be regarded as a particular branch of general blasting practice, and, though it calls for slightly different application, the general rules of blasting still hold.

Stumping powder, though somewhat less powerful, is still a high explosive in every sense of the term, and it must be treated as such through every phase of transportation, storage and blasting.

It is doubtful if two exactly similar sets of conditions could be found in any stump-blasting undertaking. Consequently the general principles can only be stated here, the particular requirements being left to the judgment and foresight of the blaster. Before any definite blasting plan is formulated a careful examination of stump and soil must be made. Thus the stump may be large, medium or small; and in any state from green to rotten. The roots may be shallow or deep, lateral, semi-lateral, or taprooted. The general texture of the soil may be clay, sand or loam, and it may be wet, moist or dry. All of these factors must be considered when estimating the required charge for any stump, yet so many combinations of the factors are possible that no definite rule can be given regarding the size of the charge. As a basis, however, it is presumed that for a green stump, under perfect blasting conditions, the final charge should be one cartridge for every 2 inches of stump diameter (estimated 1 foot above the ground).

Since the main object is to get the charge concentrated in the centre of the root system, a diagonal hole is punched with a bar or drilled with a soil auger to a point a short distance below and just beyond the centre of the stump. In the cases of small or medium stumps such a hole may be sufficiently large to hold the complete charge. However, in the case of a large stump, particularly if it is green or fresh, it may become necessary to fire a preliminary small charge of one or two cartridges. This charge is called a 'springer' and its purpose is to create a chamber at the back of the shothole that will be large enough to hold the final charge. If a 'springer' is fired, the chamber must be left to cool a while before the second charge is introduced. In case of misfire no attempt

must be made to dig into the charge or otherwise tamper with the fuse or primer. It should be reblasted in the manner already described.

Ditching: Under certain conditions drainage ditches may be blasted out economically by the so-called propagation method. The success of this comparatively modern departure often depends on technical skill and professional judgment. When a drainage plan is contemplated, the explosives suppliers or their technical representatives should be contacted for advice.

The farmer may find it necessary to resort to the use of explosives in ridding his fields of large boulders. This may be accomplished economically by what is known as 'blockholing' or 'mudcapping'.

Blockholing: A hole is drilled so that it will bottom at or near the centre of the boulder. The hole is then cleaned, loaded, stemmed and blasted in the normal manner. Stemming is important for safety as well as efficiency: the explosive must be protected from the sparks of the burning fuse. No less than 3 feet of fuse should be used. The temptation to save time with shorter fuse must be resisted.

As in the case of stump blasting, no definite rule can be given regarding the amount of charge. As a basic guide, however, one cartridge will usually be sufficient for a boulder up to about 5 feet thick.

Mudcapping: If a blockhole is not feasible the boulder may be successfully broken by blasting a sufficient charge upon the surface, preferably in a hollow, if such exists. For best results the charge should be laid on a 'cradle' of mud or soft clay on the surface of the boulder. The charge must be well

covered with mud or clay before firing, care being taken to keep the end of the fuse pointed away from the charge. The behaviour of the boulder in the wake of the blast is quite unpredictable and careful precautions must be taken against flying rock. Distance is no particular guarantee; cover should be sought behind a barricade.

Because the charge is less confined in mudcapping, considerably more explosive must be used than in blockholing to do the same amount of work. Only one charge should be fired at a time; if two charges are fired in close proximity, the first explosion will interfere with the second charge, as an explosive exerts its forces equally in all directions.

Before leaving any work on which explosives have been used, a careful check should be made to ensure that nothing of an explosive nature is left behind. Carelessness in leaving explosives lying around is undoubtedly responsible for many serious accidents to both children and adults.

It is emphasized again that surplus explosives should not be kept unless the time of use is definite. There is a widespread human tendency to keep many things 'in case they may come in handy' in the future. This temptation must be resisted where explosives are concerned. When the immediate job is finished, *all* explosives should be disposed of at once. Most dealers will cooperate by taking back any surplus in good condition. If return is not possible, advice on disposal should be sought. *Drowning explosives in water will not destroy them.*

ACCIDENTS

A classified record of all reported accidents caused by explosives in Canada is given in the Annual Reports of the Explosives Division. These reports may be forwarded to anyone interested. A study of statistics each year shows that most accidents can be placed in two broad categories; the first is accidents arising from playing with explosives which have fallen into the hands of persons ignorant of their dangerous nature; and the second is accidents directly associated with blasting.

Accidents in the first category are in the main made possible by the careless or thoughtless conduct of owners or users of explosives; their failure to keep them in proper and legal security. An example has been reported even as these words are being written.

A man went to his garage to start the tractor. While waiting for it to warm up he decided to investigate the contents of a small tin box. The lid was rusted shut so he struck it with a metal object and the tin, containing detonators, exploded. The man sustained a combined fracture of the leg and his left hand was so badly injured that he may lose it. His right eye was blown out and the sight of the left eye may be lost. A forehead wound might involve brain injury. The man may live.

This sort of accident is all too frequent. In this instance, the accident happened to an adult, but many happen to children.

The second broad category of accidents are those incidental to the use of explosives for their designed purposes. Often the cause is clearly indicated. It is

unquestionable that too frequently accidents are brought about by neglect to follow the practices described in this booklet.

In illustration of the importance of careful precautions, a few typical examples are here selected from the files of the Explosives Division, with brief appended notes in some instances.

Transportation: *Both blasting cartridges and detonators were being conveyed by two men in a mine. Initial cause of the explosion is not known, but probably the explosion of the load of cartridges on the trolley was induced by that of the detonators. Both men were killed and considerable material damage done.*

A workman carrying a carton containing dynamite and blasting caps stumbled and dropped the carton. He was killed in the explosion which followed and two companions suffered burns and shock.

Explosives and detonators must never be stored or transported together.

Storage: *Cases of dynamite were temporarily stored in a small wooden building near a boiler house. Hot ashes from the boiler house were thrown out and set fire to the shed. One man was seriously injured by the explosion that followed.*

While jumping back to avoid being hit by a flying rock, a blaster stepped on a sack containing detonators. The detonators exploded, inflicting injuries from which the blaster died.

Safety in the storage of explosives is not confined to a magazine, but applies to any sort of temporary storage. Safe storage rules must be followed until the explosives are safely in the shothole.

Preparing charges: *A miner was injured by the explosion of a detonator when he was pushing the fuse into it.*

When preparing capped fuses, the fuse should be inserted gently and never twisted. A cap should never be misused by tapping or knocking it. Cap crimpers should be used for crimping cap to fuse.

Smoking: *Men of a work party were smoking in a shack in which was an open box containing dynamite cartridges, some with detonator and fuse ready for charging. A fuse was accidentally ignited, and though all endeavoured to run clear three were injured and much material damage done to buildings.*

Sparks or Flame: *A shotfirer laid a partially filled box of detonators on the ground near the open door of a blacksmith's shop while he was fixing fuses in others. The detonators in the box were exploded, apparently by a spark from the forge alighting on them. Three men were injured.*

A miner approached an unexploded charge with an acetylene lamp and an explosion followed, killing one man and seriously injuring another.

Short Fuse: *A man was observed to prime a dynamite cartridge with detonator and fuse estimated at about 12 inches in length, intending to light it and throw it on the ice. It apparently did not ignite and he cut off a portion of it and again lit it. The cartridge exploded in his hand. He was badly maimed and died in a few hours.*

A man used a fuse, somewhat less than 3 feet long in a charge placed for blowing a pole hole. He lit it, but no explosion followed; he returned to the shot hole and made two or more attempts to light the fuse,

cutting off pieces each time. After he succeeded in starting the fuse to his satisfaction he was unable to get sufficiently clear and was seriously injured by the blast.

Three shotfirers on road work set off seven charges with 2-foot fuses. One of the men evidently had difficulty in igniting his fuse and was delayed so that he failed to get clear of the blasts. He lost a leg, had a shoulder dislocated, and suffered from other injuries.

The rule "Never use less than 3 feet of fuse" should invariably be followed.

Ramming or Stemming: *A quarryman caused an explosion of a dynamite charge by ramming it with an iron tamping rod. He was seriously injured.*

Two men were killed and one injured by the explosion of a charge when it was being rammed home. The explosion was probably due to the breaking of the cartridge and the presence of grit, the loose dynamite being exploded by friction.

Only wooden tamping rods should be used. Every shothole should be of sufficient diameter, and free from grit or other obstructions, to permit the easy access of every cartridge.

Returning to shothole too soon: *A farmer, blasting stone on his farm, thought a charge which he had ignited had failed and returned to the shothole. The charge exploded and he sustained severe injuries, including the loss of one eye and injury to the other.*

A farmer engaged in blasting a ledge in his orchard, thinking the fuse had not been properly lit, returned to the shothole to relight it. The charge exploded, killing him and injuring his sister who was nearby.

A man working with a lumber tracklaying gang lit the fuses of three shots. On hearing two explosions he returned to investigate the third charge which then exploded, killing him.

A well digger, when a blast did not shoot as soon as he expected, returned to investigate the cause. The explosion then occurred and he sustained severe injuries.

Flying Debris: *A logger blowing stumps, took cover behind a nearby tree and was killed by a piece of the stump which rebounded from a tree behind him.*

A miner who did not take the prescribed protection on firing a charge was injured on head and arms by projected debris.

A truck driver took cover by standing behind the dipped end of a truck. A piece of rock from a blast was thrown 100 yards, struck the cab of the truck, rebounded and came down on the head of the driver, fracturing his skull with fatal results.

A large piece of rock hit a worker on the foot resulting in fracture, when he was standing 150 yards from the blast.

In most blasting situations, material cover may be quite as important as distance. No one can guarantee in which direction or to what distance the debris will be projected.

Drilling into Explosives: *One man was killed when he accidentally discharged some dynamite with a power drill on a construction project.*

Great care must be taken when it is necessary to drill in a face which has been previously blasted. There may be undetonated explosives remaining, particularly in certain types of rock.

Inadequate guarding: *A seven-year-old girl was killed by a dynamite explosion when she wandered into a construction area.*

All possible approaches to a blast area must be carefully guarded. A child may not understand the shouted "FIRE" warning.

READ AND HEED

DO ONE THING at a time and do it right.

DON'T skimp the fuse.

DON'T tamper with misfires.

A DETONATOR is designed to detonate a blasting cartridge. Keep them separate till you are ready to place the charge.

DON'T crimp with your teeth. It's not a visit to the dentist you are risking.

DON'T smoke when handling explosives. If you do wish to give up smoking try a less drastic measure.

TAKE GOOD COVER from projected debris. Don't emulate the legendary ostrich, you may get it in the neck.